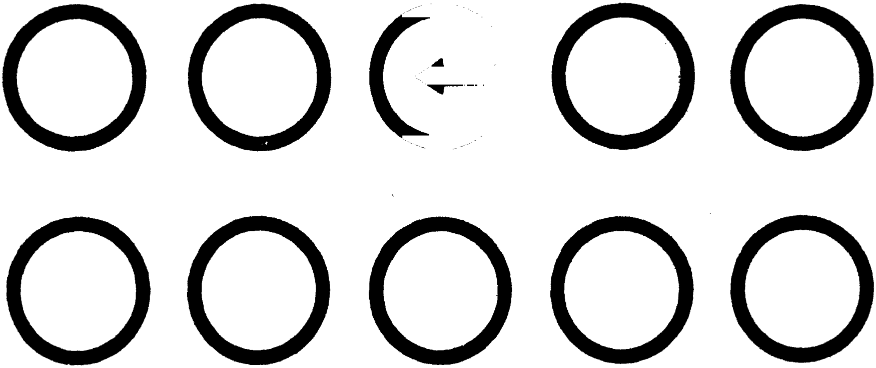
RESEARCH ABSTRACTS



RESEARCH CELL
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PREFACE

The Examination Research Cell (ERC) of the Association of Indian Universities has been from time to time investigating into various fundamental aspects of university examinations Internal Assessment, Grading, Test and item analysis, Practical Examinations to name only a few. Results of these research projects have been reported in the form of Monographs some of which have been revised to include experiences of teachers/colleges/universities during implementation, in subsequent editions.

At the same time, certain research studies have been conducted and it is felt that these have to be reported in the form of research Abstracts and three such abstracts are now getting ready.

In this third Research Abstract, the following in depth studies have been included.

1. Computer Generation of Equivalent Multiple Choice Items
2. Computer in Storing and Retrieving Question Banks
3. Random Matrices Generation
4. Computer Programme for Analysis of objective Type Test

It is hoped that teachers, papersetters, examiners and other will find the research studies and the results and conclusions will be very helpful and useful and that they will be guided to better evaluation of their students' performance.

Constructive suggestions for advancing some of these studies, will be most welcome.

New Delhi.
22nd July, 1978.

V. Natarajan

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It is not possible to acknowledge hundreds of teachers who participated actively in these researches and we are grateful to them.

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STUDY 4 : COMPUTER PROGRAMME FOR ANALYSIS OF OBJECTIVE TYPE TEST

COMPUTER GENERATION OF EQUIVALENT MULTIPLE CHOICE ITEMS

The application of the computer to the preparation of student evaluations poses some of the same problems as other applications of computers. To obtain flexibility one can store enormous volumes of data in fixed formats for rapid retrieval or one can develop a few complex algorithms to generate a large quantity of relatively different questions/items. In one case, the cost is in storage and in the other the cost is in the programme logic and computation. One can develop an application that utilizes features of both of these approaches.

There are three parts of a multiple choice item viz the stem, the correct answer (or key) and the incorrect answers (foils or distractors). It is possible now to design an item Pool Management System that permits an association of upto 7 correct answers and seven distractors with each question stem. Below is given a sample of a question with 7 viable answers and seven distractors.

SAMPLE

Which one of the following expressions or phrase must represent a rational number?

A 1	a repeating decimal
A 2	a terminating decimal
A 3	3.1415
A 4	0.333333
A 5	12/25
A 6	(.101001000100001....) + (3.010110111011110.....)
A 7	the square root of 4/9
D 1	a non terminating, non repeating decimal
D 2	the square root of 3
D 3	the square root of -4
D 4	0.232332333233332.......
D 5	35/(7 + (0.7))
D 6	$25 / \sqrt{3}$
D 7	Pi

If one assumes only one of the multiple choices will be correct, there are 245 ways that a choice can be made of one of the seven correct answers, followed by four of the distractors. Since IPMS also randomizes the arrangement of these five choices, there are a total of 29,400 various physical formats that can be generated from this single question.

It would be unwise to believe that one question could serve as 29400 distinguishable evaluation items but experience in classroom applications has indicated this to be a practical approach in making the compromise between storage and total item generation. With sufficiently large pools or banks of quality items, they can be used for pretests, self tests, practice sets as well as post evaluations. Even if a student should gain access to the question bank he could not depend on memorizing a list of letter answers. Indeed he would have to become involved in the content of each question. If the pool or bank is sufficiently large and well designed, such access may even serve valid educational objectives:

Some possible areas of subject matter that lend itself to this kind of treatment of computer generation of equivalent items are:

The stem may list a law / theory / or a principle / or a concept. 7 applications are given; 7 things which are not applications but can be mistaken to be applications can also be given. This will again generate 29,400 multiple choice items. We may think of subject area in perspective; 7 characteristics may be identified and given; 7 non - characteristics can also be given. The stem may direct the student to either identify a characteristic/ or a non characteristic.

The actual programme listing is given below:
to enable the teacher/reader to make use of it in his own area.

General Methods used in Item-Generation Programme.

This item generation programme is quite general and can be used for any number of rational, irrational choices and the programme takes the vector of Rational and Irrational choices together with the number of options required to take in a generated multiple - choice question on the input parameters.

At the first step it calculates the value of P ! where P is the number of options required to have in the questions. The feature of this value lies in the fact that of we have only one choice of a question containing P options, we can generate P ! questions, just changing the position of this entities. Then the programme produces a Matrix MGR of order (P x P !) with the help of two permutation IP1 on IP2 which contains all the P ! different permutations of P numbers. This is accomplished by calling SSP subroutine 'PPRCN' for generating permutations.

Further it generates all the elements of 2^N Factorial Experiment in the standard form where N is the length of vector of irrational choices just as for 2^3 Factorial Experiment it will generate 8 elements as

```
000    100
001    101
010    110
011    111
```

and of this, the matrix B is formed.

Then out of these 2^N Factorial Experiment, elements (with entities 0 or 1). The matrix FM is formed as containing only these rows of B matrix, whose row sum of elements came out as P-1 i.e. one less than the number of options required, in the question and this one is excluded and is kept for inserting the Rational - Choice.

As a generated question requires to have P-1 irrational choices and this is done taking the help of the generated matrix FM with the rule that

if FM (I, J) = 1 ; Ith component of vector of irrational choice should be included in the jth generated question.

if FM (I, J) = 0 ; It is not taken

Proceeding like this we can have $N_{C1} \times M_{C}(P - 1)$ total questions; where M is the length of the vector of irrational choices.

Finally w.r.t. each generated question (P) ! questions can be generated just changing their relative position, taking the help of the Matrix MGR. Thus for N rational choices, M: irrational choice and P: the option required we are able to have.

$$\binom{N}{1} \binom{M}{P-1} \times P\,!$$

total generated Multiple-choice items.

ITEM GENERATION PROGRAMME

```
Dimension  R(4), RR(8), MGR (24,4), B(256,8), FM(256,8)

             VE(4)  RA(24,4), IP1(4), IP2 (4), IP3 (4).
           READ 22, N, M, NO
22         FORMAT  (                )
           AN = N
           AM = M
           ANO = NO
           READ 1, (R(I)   , I = 1, N)
           FORMAT     (         )
           READ 1, (  RR(I), I = 1, M)
           L = NO - 2
           DO 40 I = 1, L
           IP1 (I) = I + 1
```

```
      40        IP2 (I) = I + 2
                IP1((No-1))  = NO
                IP1 (No )  = 1
                IP2 ( No )  = 1
                IP2  (( L + 1 )) = 2
                DO 30 J = 1, No
                MGR (1, J) = J
                MGR (2,J) = IP1 (J)
      30        MGR (3,J) = IP2 (J)
                DO 20I = 4, N OF
                CALLPPRCN (IP1, IP2, IP3, NO, 2, IER)
                DO 20J = 1, NO
                MGR (I, J)  = IP3 (J)
      20        IP2 (J) = IP3(J)
C               CALCULATING FACTORIAL (NO)
                NOF  = 1
                DO 111 I = 1, No
     111        NOF = NOF * I

C               GENERATING FAC. EXP. ELEMENTS
                DO 10  J = 1, M
                IN = 2 ** (J-1)
                K = 2 ** (M - J + 1)
                JP = K - 1
                DO  11  L = 1, JP, 2
                K = (L - 1)  IN + 1
                IK = L * IN
                DO  12 I = K, IK
      12        B ( I, J ) = 0.
                K = IK + 1
                IK = (L + 1) * IN
                DO 13 I = K, IK
      13        B (I, J) = 1.
      11        CONTINUE
```

```
   10     CONTINUE
C         SORTING THOSE ROWS OF B HAVING ROW SUM (NO - 1)
          LA  =  2 * *   M
          AP = 0.
          DO 100 I = I,  LA
          SI = 0.
          DO 101  J = 1,  M
  101     S1  = S1  + B (I,  J)
          AS = NO - 1
          IF  (S1. NE.  AS) Go To 100
          AP = AP + 1.
          DO 102 J = 1,  M
  102     FM (AP,  J) = B (I,  J)
  100     CONTINUE
          PRINT  500
  500     FORMAT (1H2)
          PRINT 501, (R (I),  I = 1,  N),  (RR(I),  I = 1,  M)
  501     FORMAT (//// 5x,  'RATIONAL CHOICES',  4F 4. 0,
                    /// 5x,  'IRRATIONAL CHOICES',  8F 4. 0)
          IAP = AP
          Do 201   I = 1,  N
          VE  (1) = R  (I)
          Do 201 J = 1,  IAP
          IK = 1
          Do 202   L = 1,  M
          IF  ( FM  (J, L)   .  EQ.  O.  ) Go To 202
          IK = IK + 1
          VE  (IK) = RR  (L)
  202     CONTINUE
          Do 2010  IJ  = 1,  NOF
          Do 2010  IJR = 1,  NO
 2010     RA (I J,  I J R ) = VE ( MGR ( IJ,  IJR))
          PRINT 203,  ((RA  (IZ,  JK),  JK = 1,  NO),  IZ = 1,  NoF)
```

```
203       FORMAT (/// 5x, (4F 6.0))
201       CONTINUE
          END
```

Description of Variables Used

N : Number of RATIONAL - CHOICES

M : Number of IRRATIONAL - CHOICES

NO : Options required in a generated multiple-choice item.

R : Vection of length N, of Rational-Choices

RR : Vection of length M, of irrational choices

NOF : Value of Factorial (NO)

B : Matric of order $(2^M \times M)$ of the generated Factorial Experiment elements.

FM : Matrix of order $(L \times M)$ where $L<2^M$, is the matrix derived, from B consisting of all those rows of B having row sum as (NO-1)

VE : Vectors of length No, is a generated item. like this $N_{C1} \times M_C$ (NO-1) vectors are generated.

RA : Matrix of order (NOF x NO), one such matrix is associated with each generated VE consisting of all generated questions that can be generated from the associated VE w. r. t the position of entities,

IP1, IP2, IP3 : Each is a Vector of length NO ; Dummy vectors required for generating permutations.

MGR : Matrix of order (NOF X NO) consisting of all the permutation of given NO elements.

Item generation can be attempted with less number of keys, less number of distractors also. Table below shows the range:

S. No.	Number of keys/ Number of distractors	3 option item	4 option item	5 option item	REMARKS
1	$\frac{4}{4}$	144	384M	480	
2	$\frac{5}{5}$	300	1200	3000	
3	$\frac{6}{6}$	540	2880	10800	
4	$\frac{7}{7}$	889	5880	29400	

Assuming all of the other factors related to using a computer for test generation are present, one obstacle could still prevent any widespread application. If this system requires any significant training problems, its value is diminished. To that end IPMS is itself tutorial in data entry and materials production one can use the system in the absence of any technical knowledge about computers and it does not require a trained person to stand close by for assistance. Everything that a teacher needs to know to produce materials from existing question pools can be contained lucidly and legibly on one side of 8.1/2" x 10" card. It is possible to design the system without professional programmers and using parent volunteers, students and para-professionals to enter and edit data supplied by teachers.

Much testing goes on in education but evaluation as an end in itself is not justified. IPMS encourages the user to classify each item in terms of 3 specific attributes. Choices such as chapter/section/objective or unit/subunit/objective are common choices for these attributes.

In the process of implementation, one may face the problem of changing teacher attitudes as they relate to the computer and individualization of instruction. Any innovation in Education must allow a teacher to begin at his own level of professional skill and grow into application as his skill improves. Although a result may be revolutionary, its implementation must be evolutionary. Secondly the importance of quality must be understood.

Finally no matter how great the system may seem to the author, and no matter how enthusiastically they are able to describe it, its ultimate success will be determined on the basis of whether the apparent value received is greater than the perceived effort of using it. Technology in education must be a serving tool and not an end in itself.

COMPUTER IN STORING AND RETRIEVING QUESTION BANKS

Assistance in preparation of tests and exercises is the emerging use of computers that has had very little publicity but which shows signs of widespread appeal. Computer assisted test costruction using the retrieval process is a service now available in some developing countries. Computer assistance may involve any combination of several activities.

a) The questions may be banked by a computer (and subsequently retrieved) individually to store questions, tests and exercises.

b) Questions may be classified according to content and statistical characteristics so that tests/examinations meeting carefully defined specification can be coni-figured automatically and in some cases.

c) The items/questions may be generated by the computer.

As one tries to generalise by reviewing the existing systems he is likely to be struck first by their diversity. Systems having similar test preparation functions often were developed for different reasons. Systems which were motivated by similar considerations often support somewhat different functions. Some systems restrict themselves to support test preparation, others offer test preparation as one of the several services such as test scoring. Most systems are designed to support evaluation of diagnosis, some also provide tests of question for drill or review or for self evaluation. Most computers assisted test preparation takes place in post secondary level institutions. Some deal with postgraduate certification of the military services. USA leads in exploring this field, there are similar activities either underway in Britain, Canada, Germany and Australia.

Such a service is now available to all the faculty-members and students of the California State University and colleges. The Soerates system is available to all 16,000 faculty members and more than 290,000 students, over their 19 campus computer network spanning a distance of 12,000 km. There are eleven banks from which to draw test items. The size of each bank varies from a few hundred, as in case of the 'Indtoductory Psychology Bank' to over 15,000 items as in the case of 'American History Bank'. Tests and other exercises can be generalised interactively by students and faculty at time sharing terminating through their interactive computer network. The system is functioning smoothly enough now so that, the test requested by telephone before 8 P.M., typically are delivered by the following morning.

In principle, the generation of tests by selecting questions from large collections is not new. It is tradition among teachers to keep collection of items in file-boxes or other containers and periodically to deliver stacks selected from these collections to a secretary to be typed. Moreover, computerised item-banks have been used by National Testing Services for about two decades. However, the availability of item-banks through computer network is beginning to emerge as a novel and powerful tool of the individual classroom teacher.

In India, some very recent attempts have been made by AIU (Research Cell) for the development of 'Question Bank' - the first step of this process. The need of this was felt when educationists have come round to the view that much of the fault lies in the manner in which the question-papers are set. They have quoted with approval the report of the 1966 Education Commission which stated "Most of the weaknesses in the present system of examinations are due to defects in the questions and question-papers. Very few of the paper setters possess the necessary knowledge and skill in construction of valid and reliable tests'.

The Commission urged that question-papers should be designed to test not merely the acquisition and knowledge by the candidate, but also development of his problem-solving abilities. There are numerous mistakes in grouping of questions and in framing the questions, besides there are factual and contextual errors. Often the questions set for an examination are out of course, or not quite comprehensible to the average student. Then comes the trouble walkouts, tearing of answer books and other hostile demonstrations, many of which result in smashing of chairs and tables, injuries to centre superintendents and much loss in other ways. In order to end this national waste and remove the general complaints of teachers and students, the University Grants Commission has suggested the Question Bank scheme.

As a result, AIU (Research Cell) has generated fairly big volumes of questions of different kinds. This work is meant to be an aid to teaching. Questions have been prepared by hundreds of university teachers in workshops, organised in different parts of the country. Categories like multiple-choice, matching, rearrangement, short answer, long answer etc. The questions aim at testing fifteen different objectives, like knowledge of specifics, trends, comprehension, application, analysis etc. A checklist of the criteria used for prevalidation of question and another to judge the quality of supplementary type text-items are also printed.

The key feature of each bank is the subject matter content classification system. Although experience has shown that classification system will reflect at least to some degree the personal viewpoint of item-bank co-ordinators, therefore all of the bank co-ordinators have been encouraged not to incoporate any material that could be specifically associated with particular pedagogical philosophy.

Item Selection

In most test construction systems questions are stored in computer manipulable form, so that the test itself can be easily printed. The usefulness of such systems depends of course upon the existance of data banks of machine readable questions.

Many systems are designed only to store and print questions that are specifically requested by the user. However,many other include computer-assistance in the selection of items to appear on a test. In these systems items are some how classified or associated with attributes. Then attributes may involve either characteristic assigned, like indices of discrimination.

To get assistance in selecting items, the user typically requests those having the characteristics, he desires. If more are available than were requested according to the set norms, the system generally selects at random from those eligible.

Consequently, when the system selects questions by attribute, the user does not usually have control over which the specific item will be retrieved. In such cases it is often necessary to revise the test produced initially. Test modification can be facilitated by arranging for the computer to remember the test and on the user to instruct it to delete items or to add items.

A few systems aid in test preparation by helping the test designer, to choose items but do not print the test itself. When this approach is used, the questions need not be banked in computer retrievable form only the relevant item characteristics need to be accessible the computer. The computer provides the list of items identifiers. The items are themselves retrieved from manually assessed files and the test is formatted and printed.

Computer Program for storage and Retrieval Process

The main program 'STRT' stores all the questions found in the Question Bank with the detailed description of each question i.e. for each question it stores the vector A, The array of 7 components which are

A (1) : The chapter in which the question lies
A (2) : Serial Number of the question as found in Bank
A (3) : Code of subject content within the chapter.
A (4) : Type of question
A (5) : Objective of question
A (6) : Time allocated to the Question (in Mts.)
A (7) : Marks allotted to the question.

While storing the question on tape, it also calculates the components of vector N, whose ith component denotes the number of questions found in the ith chapter of the Bank, by comparing the value of A(1), for each question with the value of TN, the variable according the previous question's chapter code, and if they happen to be the same, the component of vector N is incremented, otherwise it shifts to the next component of vector N.

The input cards, whose number is equal to the number of questions wanted to be taken, from the bank, are read one by one. Each card contains the desired discription of question wanted to be taken out, which is stored in vector B of 6 components:

B (1) : The chapter code from which the question is to be taken
B (2) : Subject-content within that chapter
B (3) : Type of Question Desired

B (4) : Objective of Question wanted to be taken out

B (5) : Time given to this question

B (6) : Marks allotted to this question

```
C         MAIN PROGRAM STRT
          DIMENSION A(7), N(10), B (6), C(5000, 7)
          DATA NS, NT, NQ, NQD / 10, 580, 500, 15/
C         STORAGE AND FINDING VECTOR N
          I = 1
          TN = NT
          DO 2 J = 1, NQ
          READ (3.20) (A (I), I = 1, 7)
   20     FORMAT (2 F 4. 0, F 5.1, 2 A 2, 2 F 3. 0)
          WRITE (3) A
          IF (TN. NE. A(1) ) GO TO 13
    5     N (I) = N(I) + 1
          GO TO 2
   13     I = I + 1
          IN = A(1)
          GO TO 5
    2     CONTINUE
          PRINT 500
  500     FORMAT ( // 5 x, 'NUMBER OF QUESTIONS IN EACH CHAPTER //)
          PRINT 501, ( ( I, N (I), I = 1, NS)
  501     FORMAT (5 x, 2 I 8)
C         RETRIEVING AND FINDING QUESTIONS ACCORDING TO SET NORMS
          PRINT 14
   14     FORMAT ( // 5x, 'DESCRIPTION OF THE SET QUESTIONS', 5x,
          TOTAL NUMBER OF QUESTION FOUND IN BANK OF THIS KIND')
          DO 5 I = 1, NQD
          REWIND (3)
          READ 21, B
   21     FORMAT (F 4. 0, F5. 1,4A 2, 2F 3. 0)
C         FINDING TO WHICH CHAPTER THE QUESTION BELONGS
          LPP = B(i)
          IAB = LPP - NT - 1
          IF (IAB  .EQ. 1) GO TO 6
          IA = IAB - 1
    6     DO 7 I = 1, IA
    7     IS = IS + N (I)
C         THIS IS A DUMMY READ STATEMENT TO REACH TO THAT POINT
          OF THE TAPE ON WHICH THE QUESTIONS OF THIS CHAPTER ARE
          STORED
          DO 8 J = 1, IS
          READ (3) A
    8     CONTINUE
          IS = IS + 1
```

```
        GO TO 9
        IS = 1
    9   IZ = 0
        IP = N (IAB)
        DO 10  K = IS, IP
        READ (3) A
        DO 11 IK = 3, 7
        IL = IK - 1
        IF ( A (IK)  .NE.  B (IL) ) GO TO 10
   11   CONTINUE
        IZ = IZ + 1
        DO 12 IK = 1,  7
   12.  C(IZ ,  IK) = A (IK)
   10   CONTINUE
        IF (IZ.EQ. 0) GO TO 200
        IF (IZ.  EQ.  1) GO TO 201
        K = IZ / 2
  203   PRINT 13,  (C (K,  I),  I = 1,  7),  IZ
   13   FORMAT (2F 4. 0,  F 5.1,  2A2,  2F3. 0,  I4)
        GO TO 5
  200   PRINT 202
  202   FORMAT (// 5x, 'NO QUESTION OF THESE SPECIFIED NORMS
        IS FOUND IN THE BANK')
        GO TO 5
  201   K = 1
        GO TO 203
    5   CONTINUE
        STOP
        END
```

Description of Variables Used

A : Array of 7 components, giving the description of a question

N : The vector of components, equal to the number of chapters in the Bank, whose ith component tells the number of questions in the ith chapter of Bank.

B : INPUT vector of 6 components giving the description according to which the question has to be retrieved.

NS : Number of Chapters in the Bank

NT : Code of the Ist Chapter in the Bank

NQ : Number of question in the Bank

NQD : Number of questions wanted to be taken out

With this kind of information, for each question computer firstly calculates the serial number of the chapter to which the question belongs and then calculating the number of questions, which are lying before this specified chapter. The tape is moved forward by means of dummy read, so that the Retrieval - Process is carried on from the suitable point.

After the tape is brought to the point where that chapter's questions are stored, scanning is done for each question taken from that point uptill the end of that chapter. The questions found to have the norms found in the Bank of this specified description is noted and given as an output. Then a random selection is made from the obtained questions and their identifying characteristic together with serial number as found in the bank is given as an output.

Whether items are retrieved or generated, there are several possible versions. In many cases, exams, are printed directly on reproduction masters. In some systems the test can be printed in several scrambled versions (i.e. the same list of items).

Benefits

System which print tests have the obvious advantage of reducing the clerical chores of users and providing error free text. System which also aid in item selection make questions conveniently available, without the need for users to tediously search from the item text on item - characteristics. The educator can produce tests carefully tailored to meet the instructional needs as he defines.

When the large number of questions become available then the problem of test security practically disappears.? The question - paper leakage scandals will end. These scandals arise from the secrecy that is at present sought to be maintained - often in vain. The question papers before and after printing pass through so many hands that secrecy is very difficult to maintain.

Thirdly, the system will be economical. We are satisfied that the system if used, surpass our minimum expectation for it - that of providing multiple versions of examination on duplicating masters to be typed, by a secretary and far less than the same amount of instructional material to be covered by on his inter active CA I, a typical test containing 100 items selected questions only throughout a bank required 1.07 minutes total computer time at a cost of $ 3.46, obviously a prudent use and this remains less expensive than its manual counter part.

Surely this service with added feature of automatic scoring and item recorded maintenance will be seen by faculty as leading to further freedom for educational innovation, particularly in the areas, of the modern approach to self paced instruction in self testing and even in traditional lecture examination teaching.

How far Accepted

It might be added that the several universities in India have already introduced the 'Question Bank scheme. Bombay University one of the oldest in the country has initially decided that to begin with 15% of the questions will be selected from the Banks. Berhampur University has already introduced the scheme fully. Calicut University has also started the experiment though only for few courses. Patna University has established 'Question Bank for Physics initially. Rajasthan University has arranged a series of workshops for setting up these Banks. Madras, Mysore, Madurai, Jabalpur, Gujarat, South Gujarat, Poona, have all with the help of a series of Question Bank workshops conducted by AIU, developed their own Question Bank systems. Many other universities are adopting the Question Banks develped by AIU. It is true that the experiment has just been started that too with only one aspect. None of the Indian Universities has yet started the storage and retrieval process with computer and for test preparation.

Not only in India, the developing countries which are leading in these activities and where although more than one hundred educational institutions have developed, collection of question stored on the magnetic tape. It appears that the teachers at these institutions make only marginal use of them, partly because of old habits, partly because of publicity about the bank and partly because of the mistaken belief that the operating knowledge of sophisticated gadgety is necessary.

We are not discouraged by the slow acceptance of the usefulness of item banks, if for no reason than that they have great promise in allowing us to do what we are already doing but for more students at various levels of progress, cheaper, more quickly and with fewer errors.

It is well known that innovative products and methods require years even decades to achieve full acceptance. Macluchan's observation that 'In the age of Xerox, every man is a publisher" is even more appropriate for information retrieval from computers. We think that awakening has occured but beast is still groggy.

RANDOM MATRICES GENERATION

The fact that multiple-choice test items can be marked either one or zero depending on whether the examinee has opted for the key response or not, has lead the researcher a new point.

Suppose a multiple choice test consisting of three items were taken by the four examinees where each of the item has three options (The result is immaterial for the number of options taken) Their options when compared with the key responses will yield the score matrix of order (4 x 3) it is found to be:

Table of Scores

Examinees/items	I	II	III
1	0	0	1
2	0	1	1
3	0	0	0
4	0	0	1

(A)

Thus an examinee scores on these three items will coincide with one of the 8 (=2^3) possibilities.

0	0	0
0	0	1
0	1	0
0	1	1
1	0	0
1	0	1
1	1	0
1	1	1

(B)

If there are three items and four examinees. Then the matrix as shown in (A) will be (4x3). The fact that any row of this matrix is one of the rows as shown in (B) proves that there are:

$$ {}^{8}C_{1} \times {}^{8}C_{1} \times {}^{8}C_{1} \times {}^{8}C_{1} = 4 \times {}^{8}C_{1} $$

possible ways of obtaining the score matrix as in (A): Then for each of the hypothetical configuration of the matrix (A) can be analysed for the objective type test analysis.

The following computer program generates some of the hypothetical configuration and finds the Mean, variance, together with the values of Kuder Richardson Reliability and Index of measurement efficiency.

DESCRIPTION AND METHODOLOGY USED IN COMPUTER-PROGRAMME

N : The number of Examinees
M : The number of items
IB : Matrix of order $(2^M, M)$

PART I of the Program computes the matrix IB.
Which is same as (B), shown in illustration,
Where M = 3.

IP1, IP2, IP3 : Vectors of length 2^M. used to generate the permutation of the elements
1, 2, 3, _________, 2^M

PART II of the Program generates the permutation with the help of SSP subroutine PPRCN, description of variables are as follows

PPRCN (IP1, IP2, IP3, IK, 2, IER)

where IP1, IP2, are the given permutation of integers from 1 to IK.

IP3 is the generated permutation
IK : length of any of the vectors IP1, IP2, or IP3

With the help of the generated permutation, IP3 of length 2^M. The program splits the vector IP3 into KL $(=2^M/N)$ parts. The First part NP1 which consists of the elements IP3 (I), IP3(2), --------, IP3 (N) the second part NP2 which consists of the elements IP3(N+1), IP3(N+2), --------, IP3(2N) and so on.

Taking any part, say NPI, of IP3 computer generates a matrix AID of order (N x M) whose K^{th} row is some as that of $(NPI(K))^{th}$ row of matrix IB.

Thus with each permutation generated the program generates KL $(=2^M/N)$ Matrices AID of order (N x M), Then for each, Matrix AID the statistical concepts MEAN, VARIANCE of Total scores is found with the help of the subroutine EMV, together with the values of Reliability as calculated by the Kuder - Richardson formula and that of Index of Measurement Efficiency.

PART III computes the values of upper bound and lower bound (other than zero)

i. Mean of scores
ii. Variance of scores
iii. K. R. R. of scores
iv. Standard deviation of scores
v. Index of Measurement Efficiency.

This work is accomplished by the subrontive AMA.

```
C        MAIN PROGRAMME

         DIMENSION
         N=10
         M=5
         AM= M
         AN=N

C        PART I

         DO I J = 1, M
         IN  =  2 * * (J - 1)
         K   =  2 * * (M-J+1)
         JP  =  K - 1
         DO4L = 1, JP, 2
         K   =  (L - 1) * IN + 1
         IK  =  L*IN
         DO 11 I = K, IK
   11    IB(I, J)  = 0
         K = IK + 1
         IK = (L + 1) *IN
         Do  12 I = K, IK
   12    IB (I, J)  = 1
   4     CONTINUE
   1     CONTINUE
         READ 41, (IP1 (I), I = 1,  IK), (IP2 (I), I = 1, IK)
   41    FORMAT (          )
         PRINT 500
   500   FORMAT (IH2)

C        PART II

         L = IK/N
         DO 110 KJ = 1, 100
         CALL PPRCN (IP1, IP2, IP3, IK, 2, IER)
         DO 100 I = 1, L
         IZ = (I - 1) * N + 1
         IF = I * N
         K = 0
         DO 200 J = IZ, IF
         K = K + 1
         IJ = IP3 (J)
         DO 200 IP = 1, M
   200   AID (K, IP)  = IB (IJ, IP)
         CALL EMV (AID, AM, AN, AEM, AV, AAK, ASD, AIME)
         EM (KJ, I) = AEM
         V (KJ, I) = AV
         AK (KJ,  I) = AAK
         SD (KJ, I) = ASD
         BIME  (KJ, I) = AIME
```

```
      100       CONTINUE
                DO 120 J = 1,  IK
                IP2 (J) = IP3 (J)
      110       CONTINUE

C               PART  III

                CALL AMA (EM,  100,  L,  BM,  BSM)
                CALL AMA (V,  100,  L,  BV,  SV)
                CALL AMA  (AK, 100, L, BR,  SR)
                CALL AMA  (SD, 100, L, BSD, SSD)
                CALL AMA  (BIME, 100, L, BIM, SIM)
                PRINT 7001

      7001      FORMAT (//20 x 'UPPER - LOWER SOUND AS CALCULATED FROM GENE-
                RATED MATRICES'//)
                PRINT  7002, BM, BSM, BV, SV, BR, SR, BSD, SSD,  BIM, SIM,

      7002      FORMAT (5x,  'MEAN OF SCORE', 6x, 2F15.4, // 5x,  'VARIANCE OF
             1  SCORE', 2x, 2F15.4// 5x, 'K.R.R.  OF SCORE',  6x, 2F15.4, //
             2  5x, 'S.D.  OF  SCORE', 8x, 2F15.4, // 5x, 'I. M. E.  OF  SCORE',
             3  3x, 2F15.4, //)

                END
```

<u>SUBROUTINES USED</u>

```
SUBROUTINE EMV (AID, AM, AN, AEM, AV, AAK, ASD, AIME)
DIMENSION AID (   ),  S  (    )

      S1 = 0.
      S2 = 0.
      M = AM
      N = AN
      DO 1 I = 1, N
      S(I) = 0.
      DO 2  J  = 1,  M
2     S(I) = S(I) + AID (I, J)
      SI = S1  + S(I)
1     S2 =    S2 + S(I) * S(I)
      AEM = S1 /AN
      AV = (S2 - AN * AEM * AEM) / AN
      Z1 = 0.
      DO 3 J = 1,  M
      S3 = 0.
      DO 4  I = 1,  N
4     S3 = S3 + AID (I, J)
3     Z1 = Z1 + S3 * (AN - S3)
      AAK = 1.  - Z1 / (AN*AV*AN)
      AAK = AM*AAK / (AM - 1.)
      ASD = SORT (AV)
      AIME = 1. - (.16 *AM) /AV
      RETURN

      END

      SUBROUTINE AMA (EM, 100, L, BM, BSM)
      DIMENSION EM (100, L)

      BM = 0.
      BSM = 0.
      DO 1 I = 1, 100
      DO 1 J = 1, L
      IF (EM (I, J).EQ. 0.) GO TO 1
      IF (EM (I,J) . GT. BM) BM = EM ( I,J)
      IF (EM (I,J) . LT. BSM) BSM = EM (I,J)
1     CONTINUE
      RETURN
      END
```

OUTPUT OF THE PROGRAMME

In our specific problem, computer generates 300 hypothetical configurations for the Multiple -choice test consisting of 5 items and 10 examinees. Programme analyses each of the generated score - matrix.

Such results of 10 generated matrices is given below:-

MEAN	VARIANCE	KUDER RICHARDSON RELIABILITY	STANDARD DEVIATION	INDEX OF MEASUREMENT EFFICIENCY
2.5	1.2500	0.0200	1.1180	0.3600
2.2	0.7600	-0.0625	0.8718	0.0526
2.8	1.1600	0.0216	1.0770	0.3103
1.7	1.0100	-0.0990	1.0050	0.2079
3.0	1.4000	0.2143	1.1832	0.4286
2.9	1.2900	0.1357	1.1358	0.3798
2.0	0.4000	-2.4375	0.6325	-1.0000
2.3	1.6100	0.3261	1.2689	0.5031
1.9	1.2900	0.1744	1.1358	0.3798
2.6	1.2400	0.1008	1.1136	0.3548

Here below, we present the table consisting of Upper/Lower bounds for the statistical concepts taken into analysis. (as based on 300 generated configurations)

Upper/Lower Bound as Calculated from 300 Random- Matrices

	Upper Bound	Lower Bound
Mean	3.200	0.0
Variance	2.2400	0.0
Kuder Richardson Reliability	0.5915	-4.8957
Standard -Deviation	1.4967	0.0
Index of Measurement-Efficiency	0.6429	-2.3333

COMPUTER PROGRAMME FOR ANALYSIS OF OBJECTIVE TYPE TEST

It is more useful to present a single general programme that will provide the teachers and researchers with a detailed and complete analysis of the test. The programme is written in Fortran IV on the IBM 360 and it is reasonably easy to adopt for use on any system having FORTRAN IV compiler.

Data cards giving the following information has to be prepared.

Data Card No.	Information Stored
1	Number of students (=N) and that of items (=M)
2.	Any set of N/2 integers from the integers 1 to N
3	Values of Roll - Numbers of the N students
4	KEY - RESPONSE OF M items
5	A Matrix T of order (N X M) giving the N students options on the M items. (it has to be punched row wise) there will be N cards describing the matrix T.

The working of programme is divided in six parts each part accomplishes the following task:

PART	FUNCTION
1.	Compares each student's option on every item. With the key Response of the item and generates a matrix CM, whose $(i,j)^{th}$ element is = 1 ; if the ith student has opted for the Key Response on the jth item = 2 ; if it is left blank = 0 ; other wise it computes the total score of each student and splits the total according to First second half, odd - even split and Random half:
2	Arranges the students in descending order w. r. t. the total score. Also changes Roll No, students' option, and the matrix CM appropriately.
3.	Provides the Mark - Frequency table

4 Calculates some statistical concepts like Mean, Mode, Variance, S. D., S. D. (By Paul Dieteich Method) and Median.

5 Finds out value of Reliability of the test by various methods such as split halve (Spearman Brown), Rulon; Flangan, KR - 20, KR21, Tuckers' modified, Stanley Approximation and by Analysis of variance approach.

6 Prepares the Derived score Table and the Question - analysis table. Question - Analysis Table consists of Choice, Mean Ability, Facility, Discrimination indices. Derived Score table has Z, T, AGCT and CEEB scores of each examinee.

```
C         MAIN PROGRAMME

          INTEGERRNO
          REALOT, KR20, KR27, KR21

          DIMENSION

          DATA H/'H'/
          READ 411, N, M
  411     FORMAT  (    )
          K = N/2
          READ 412, (IRAN (I), I = 1, K)
  412     FORMAT  (  )
          AN = N
          AM = M
          READ 1, (RNO (I), I = 1, N)
  1.      FORMAT (20I4)
          READ2, (Q(I), I = 1, N)
  2       FORMAT  (50A1)
          DO 31I = 1, N
  31      READ2, (T(I, J), J = 1, M)
          PRINT 500
  500     FORMAT (IH2)
          PRINT 60, (Q(J), J=1, M)
  60      FORMAT (2X, 'ORIGINAL DATA', //, 2X, 'KEY RESPONSE', 2X, 50A1, //, 2X,
        1 'S. NO  ' ,  5X, 'ROLL NO', 5X, 'STUDENTS RESPONSE', ///)
          DO 62I = 1, N
  62      PRINT 61, I, RNO (I), (T(I, J), J = 1, M)
  61      FORMAT (2X, I5, 5X, I5, 5X, 50(A1, IX), 5X, F4. 0)

C         PART I

          DO 7I = 1, N
          DO7J = 1, M
          IF (T(I, J). EQ. Q(J))GOTO8
          IF (T(I, J). EQ. H)GOTO9
          CM(I, J) = 0.
          GOTO7
  8       CM(I, J) = 1.
```

```
         GOTO7
   9     CM(I,J) = 2.
   7     CONTINUE
         DO10I = 1,N
         DO10J = 1,M
         IF(CM(I,J).EQ.2.)GOTO10
         RT(I) = RT(I) + CM(I,J)
   10    CONTINUE
         DO11I = 1,N
         DO12J = 1, M, 2
         IF (CM(I,J).EQ.2.)GOTO12
         OT(I) = OT (I) + CM (I,J)
   12    CONTINUE
   11    ET(I) = RT(I)-OT(I)
         L = M/2
         DO13I = 1,N
         DO14J = 1,L
         IF (CM(I,J).EQ.2.) GOTO14
         FH (I) = FH (I) + CM (I,J)
   14    CONTINUE
   13    ALH(I) = RT(I)-FH(I)
         DO15I = 1,N
         DO16J = 1,L
         K = IRAN (J)
         IF(CM(I,K).EQ.2.) GOTO16
         RH(I) = RH (I) + CM (I, K)
   16    CONTINUE
   15    RHO (I) = RT(I) - RH (I)
         PRINT 500
         PRINT 50122
   50122 FORMAT (2X, 'S.NO.', 2X,'ROLL NO', 5X,'TOTAL',5X,'ODD - EVEN',
        1 8X,'FIRST-SECOND',5X,'RANDOM-HALF'//)
         DO50121I = 1,N
   50121 PRINT5011,I,RNO(I),RT(I),OT(I),ET(I),FH(I),ALH(I), RH(I),RHO(I)
   5011  FORMAT (2X,2I5,F5.0,3(2(2X,F4.0),3X))
         CALL COR (FH,N,ALH,AK2,VF,VAL,VD2)
         CALL COR (RT,N,OT,AK4,VT,VO,VD4)
         CALL COR (OT,N,ET,AK1,VO,VE,VD1)
         CALL COR (RH,N,RHO,AK3,VRH,VRO,VD3)

C        PART II

         JM = 1
         JIM = 1
         SMA = RT (I)
         BIG = RT(1)
         DO8991I = 2,N
         IF (RT(I).GT.BIG)GOTO8992
         IF (RT(I).LT.SMA)GOTO8993
```

```
      GOTO8991
8992  BIG = RT(I)
      JM = I
      GOTO8991
8993  SMA=RT(I)
      JIM=I
8991  CONTINUE
      SAM=SMA
      MRR=RNO(JM)
      MIRR=RNO (JIM)
      DO8900J = 1, M
      Z(J) =T(JM, J)
      CFMP(J) =CM(JM, J)
      TT(J) = CM(JIM, J)
8900  AGCT(J) = T (JIM, J)
      DO17I = 1, N
      IC = RT (I)
      JJ = I
      IN = I + 1
      IRNO = RNO (I)
      IRNO= RNO (I)
      DO 140J = 1, M
      CPMP(J) =CM(I, J)
140   T1(J) = T(I, J)
      DO18J = IN, N
      IF(RT(J). GT. RT(I))GOTO19
      GOTO18
19    RT(I) = RT (J)
      JJ = J
18    CONTINUE
      IF(JJ. EQ. I)GOTO 17
      RT(JJ) = IC
      RNO (I) = RNO (JJ)
      RNO (JJ) = IRNO
      DO141J = 1, M
      CM(I, J) = CM(JJ, J)
      CM(JJ, J) = CPMP (J)
      T(I, J) = T (JJ, J)
141   T(JJ, J) = T1 (J)
17    CONTINUE
      RNO(1) = MRR
      RNO (N) = MIRR
      RT(1) = BIG
      RT(N) = SMA
      DO 6199J = 1, M
      T(1, J) = Z(J)
      T(N, J) = AGCT (J)
      CM(1, J) = CFMP (J)
```

```
 6199     CM(N,J) = TT(J)
          PRINT 500
C         PART III

          PRINT601
 601      FORMAT (5X, 'S. NO. ', 5X, 'MARKS', 5X, 'FREQ', 5X, 'CUM FREQ', /////)
          PRINT600
          I = 0
          DO105J = 1, M
          F (J) = 0.
          AJ = J
          DO116IJ = 1, N
          IF(RT(IJ). EQ. AJ)F(J) = F(J) + 1.
 116      CONTINUE
          IF(F(J). EQ. 0. )GOTO105
          DO23356KPL = 1 , J
 23356    CF(J) = CF (J) + F (KPL)
          I = I + 1
          PRINT108, I, AJ, F(J), CF(J)
 105      CONTINUE
 108      FORMAT (2X, I8, 5(5X, F8,2), 19)
          PRINT500
          PRINT82020
 82020    FORMAT (////, 5X, 'ORIGINAL DATA ARRANGED IN DESCENDING ORDER', //)
          DO82022I = 1, N
 82022    PRINT61, I, RNO(I), (T(I, J), J = 1, N), RT (I)

C         PART IV

          DO31I = 1, N
          SI =SI + RT(I)
 31       S2 = S2 + RT (I) * RT (I)
          AMEAN = S1 /AN
          BIG = 0.
          DO32J = 1, M
          IF(F(J). GT. BIG)GOTO32324
          GOTO32
 32324    BIG = F (J)
          L = J
 32       CONTINUE
          AMODE = L
          L = N/2
          IL = 2 * L
          J = L + 1
          IF (IL. EQ. N) GOTO33
          AMED = RT (J)
          GOTO34
```

```
   33      AMED = .5 * (RT(L) + RT (J) )
   34      VAR = (S2 - S1 * AMEAN) / AN
           SD = SQRT (VAR)
           ALL = (AN/2.) + .5
           IP = (AN/6.) + .5
           DO36I = 1, IP
   36      W1 = W1 + RT (I)
           IT = N - IP + 1
           DO38I = IT,  N
   38      W3 = W3 +  RT (I)
           SDPD =(W1 - W3)/ALL
           SEM = SD / SQRT (AN - 1)
C          TO PRINT OUTPUT
           PRINT 500
           PRINT 66
  600      FORMAT (5X, 48 (2H--))
           PRINT 600
   66      FORMAT (//, 15X 'TABLE OF SOME DESIRED STATISTICS', ///)

           PRINT67, AMEAN, AMED, AMODE, VAR, SD, SDPD, SEM
   67      FORMAT (5X, 'MEAN OF SCORE', 17X, F10.4, ///, 5X, 'MEDIAN OF
         1 SCORE',  15X, F10.4, //5X, 'MODE OF SCORES', 12X, F10.4, ///, 5X, 'VARIANCE
         2 OF SCORE', 10X, F10.4, ///, 5X, 'S.D.',  10X, F10.4, //, 5X, 'S.D BY DIETICH
         3 METHOD', 2X, F10.4,  ///, 5X, 'STANDARD ERROR OF MEAN', 2X, F10.4)
           PRINT600
C          PART V

C          CALCULATING RELIABILITIES BY VARIOUS METHODS
           SW1 = (2. *  AK1) / (1.  + AK1)
           SW2 = (2. *  AK2) / (1. + AK2)
           SW3 = (2. *  AK3) / (1. +AK3)
           ROE = 1.  - VD1/VT
           RFS = 1.  - VD2/VT
           FOE = 2. * (1. -(VO+VE)/VT)
           FFS = 2.  *(1. -(VF + VAL)/VT)
           FRO = 2. * (1. -(VRH + VRO)/VT)
           RRO = 1.  = VD3/VT
C          ANALYSIS OF VARIANCE  APPROACH
           AF = (S1* S1)/(AM  AN)
           SSE  = S2/AM-AF
           DO74J = 1, M
           DO73I = 1, N
           IF(CM(I,  J). EQ. 1.)GOTO75
           IF(CM(I, J). EQ. 0.)GOTO76
           GOTO73
   75      CR(J) = CR (J) + 1.
           GOTO73
   76      WR(J) = WR (J) + 1.
```

```
73      CONTINUE
        SC = SC + CR (J)
        SW = SW + WR (J)
        VVAR (J) = WR (J) * CR (J)/(AN*AN)
        Z12 = Z12 + WR (J)* CR (J)/ (AN* AN)
74      Z1 = CR(J) * CR (J) + Z1
        SSI = Z1/AN - AF
        TSS = (SC* SW)/(SC+SW)
        SSR = TSS - SSI - SSE
        Z1 = AM - 1.
        Z2 = AN - 1
        Z3 = Z1 * Z2
        AMSI = SSI /Z1
        AMSE = SSE / Z2
        AMSR = SSR / Z3
        VI = AMSI / AMSR
        VE = AMSE / AMSR
        RAV = (AMSE - AMSR) / AMSE
        PRINT 500
        PRINT 750
750     FORMAT (20X,'ANALYSIS OF VARIANCE TABLE',//)
        PRINT 600
        PRINT 760
760     FORMAT (5X, 'SOURCE OF', 5X, 'SUM OF SQUARES', 5X,'DECRRES OF',
      1 5X,'MEAN  SQUARES',5X,'VARIANCE RATIO',/,5X,'VARIATION' 5X,
      2 'FREEDOM', 28X, 'ERROR')
        PRINT 600
        PRINT77,SSE,Z2,AMSE,VE,SSI,Z1,AMSI,VI,SSR,Z3,AMSR
77      FORMAT (5X 'EXAMINEES', 5X,F15.4,//5X,'ITEMS', 8X,F15.4,5X,F8.0,
     1  10X,F15.4,5X,F15.4,//,5X,'REMAINDER', 8X,F12.4,5X,F8.0,10X,F15.4,
     2  5X,F15.4,2X)
        PRINT 500
        PRINT 68
68      FORMAT(///,10X,'RELIABILITY OF THE TEST',////,5X,1. SPLIT HALVE',
     1  //)
        PRINT69,AK1,AK2,AK3
69      FORMAT (8X 'ODD-EVEN SPLIT'  8X,F8.4,/,8X,'RANDOM HALF SPLIT'.,
     1  5X,F8.4,/,8X, 'FIRST-SECOND HALF',3X,F8.4,//)
        PRINT 70
70      FORMAT (5X,'2.  SPEARMAN BROWN WHOLE TEST RELIABILITY',//)
        PRINT 69,SW1,SW2,SW3
        PRINT71
71      FORMAT(5X,'3. RULON FORMULA OF RELIABILITY',//)
        PRINT 69, ROE,RFS,RRO
        PRINT72
72      FORMAT (5X,'4. FLANGANS FORMULA OF RELIABILITY',//)
        PRINT600
        AMR = (AK4* SQRT(VT)-SQRT(VO))/SQRT(VT+VO-2* AK4 * SQRT(VT *VO))
        PRINT730,AMR
```

```
  730     FORMAT (///,5X,'RELIABILITY BY MOISER SHORT CUT METHOD',F8.4)
C         INTERNAL CONSISTENCY RELIABILITY ESTIMATES
          S5 = 0.
          S4 = 0.
          L1 = AN  * 27./100.
          AAL = L1
          DO80J = 1, M
          WR27 (J) = 0.
          CR27 (J) = 0.
          DO81I = 1, L1
          IF(CM(I,J).EQ.1.)GOTO82
          IF(CM(I,J).EQ.2.)GOTO811
          WR27(J) = WR27(J)+1.
          GOTO811
  82      CR27(J) = CR27(J)+1.
  811     IF(J.EQ.1) GOTO81112
          GOTO81
  81112   S4 = S4 + RT(I)* RT(I)
          S5 = S5 + RT (I)
  81      CONTINUE
          IZZ = N - L1+1
          DO831 = IZZ, N
          IF(CM(I,J).EQ.1.)GOTO84
          IF (CM(I,J).EQ.2.)GOTO89
          ACR27(J) = AWR27(J) + 1.
          GOTO89
  84      ACR27(J) = ACR27(J) + 1.
  89      IF(J.EQ.1)GOTO89909
          GOTO83
  89909   S4 = S4 + RT(I) *RT (I)
          S5 = S5 + RT(I)
  83      CONTINUE
  80      SIGMA = SIGMA + (WR27(J)+AWR27(J))* (CR27(J) + ACR27(J))/(AAL * AAL * 4
          AZ = 2. * AAL
          S5 = S5 / AZ
          VAR27 = (S4 - AZ    S5)/AZ
          KR20=AM  *(1.-Z12/VT)/(AN - 1.)
          KR27 = AM  *(1.-SIGMA/VAR27)/(AM - 1.)
          AKR20=AM *  (AM *VT-AMEAN*  (AM-AMEAN))/((AM-1.)*  AM *VT)
          S8 = 0.
          S5 = 0.
          S9 = 0.
          S6 = 0.
          S7 = 0.
          DO85J = 1, M
          S6 = S6 + WR(J)/AN
          S5 = S5 + CR(J)/AN
```

```
      S8 = S8 +(CR (J) * WR(J)) /(AN * AN)
85    S9 = S9 + (CR(J) * CR(J))/(AN*  AN)
      XP = S5 / AM
      XQ = S6 / AM
      VARP = (S9 - AM * XP  * XP)/AM
      TMKR = AM * (VT-AM * XP  * XQ+AM * VARP)/ (VT*  (AM-1.))
      KR21 = AM   (VT-AM* XP * XQ)/((AM-1.)   VT)
      COEF = AM * (VT - S8) /((AM-1.) * VT)

C     PART VI

C     QUESTION ANALYSIS TABLE
      SW = 0.
      DO95J = 1, M
      DO96I = 1, N
      IF(CM(I,J).EQ.2.)GOTO97
      C(J) = C(J) + 1.
97    IF(CM(I,J).EQ.1.)AI(J) = AI(J) + RT(I)
96    CONTINUE
      CI(J) = C(J)  *100./AN
      A1(J) = AI(J)/C(J)
      FI(J) = (CR27(J) + ACR27(J))/(2. * AAL)
      DI(J) = (CR27(J) - ACR27(J))/AAL
      SW = SW + DI (J)  * SQRT (VVAR(J))
      SUD = SUD + DI (J)
      SFF = SFF + FI (J)/100.
      SFF2 = SFF2 + FI(J) *FI (J)/10000.
95    CONTINUE
      ACOEFF = AM * (1.-S8/(SW * SW))/(AM-1.)
      SATR = AM * (1.-6. * (SFF - SFF2)/SUD)/(AM-1.)
      AIME = 1.-(.16   AM)/VT
      PRINT100,KR20,KR27,AKR20,KR21,COEF,COEFF,SATR,AIME
100   FORMAT (///,5x,'RELIABILITY BY KR-20 FORMULA', 12x, F10.4
     1,/,5x, 'KR-20 FORM. BASED ON 27% HAG AND 27% LAG', F10.4
     2,/5x, 'ANOTHER FORM OF KR-20 FORM', 15x, F10.4, /, 5x,
     3'RELIABILITY BY KR-21 FORM.', 18x, F10.4, /, 5x, 'CRONBACK
     4COEF ALPHA', 20x, F10.4/, 5x, 'LOWER BOUND ESTIMATE OF
     5EXAM  RELIABILITY',10x, F10.4/,5x, 'STANLEY APPROXIMATION',
     622x, F 10.4, /, 5x  'INDEX OF MEASUREMENT EFFICIENCY', F25.4///)
      PRINT66666, RAV, TMKR
66666 FORMAT (5X,'RELIABILITY BY ANALYSIS OF VAR.', 2X, F15.4, //, 5X, 'TUCKER
      MODIFIED K-R FORM.', 2X, F15.4, ///)
      PRINT 600
      PRINT500
      PRINT 101
101   FORMAT(//,15X,'QUESTION ANALYSIS TABLE',///)
      PRINT 600
      PRINT 102
102   FORMAT(1X,'QN.NO',2X, '%CHOOSING',2X,'MEAN ABILITY',2X,'FACILITY'
    1  ,2X,'DISCRIMINATION',2X,'VARIANCE',/1X,'NO',2X 'QUESTION',6X,'INDEX ,
    2  //)
       PRINT600
       DO103J = 1, M
103    PRINT 104, J, CI (J), AI(J), FI(J), DI(J), VVAR(J)
104    FORMAT (I4, F12.4, 2F 12.4, 2X, 2F 15.6)
       PRINT 600
       PRINT 500
       PRINT 109
109    FORMAT (25X, 'DERIVED SCORE TABLE', ///)
       PRINT 600
       PRINT 6001
6001   FORMAT (///, 2X, 'S. NO. ', 2X, 'MARKS', 2X, 'Z-SCORE', 2X, 'T-SCORE',
    1  2X, 'AGCT-SCORE' , 2X, 'CEEB - SCORE', /////)
       DO6099J = 1, N
       Z(J) = (RT(J) - AMEAN)/SD
       TT(J) = 50. +10. * Z(J)
       AGCT(J) = 2. * TT(J)
       CEEB(J) = 10. * TT(J)
6099   PRINT6098, J, RT(J), Z(J), TT(J), AGCT(J), CEEB (J)
6098   FORMAT (2X, I3, 2X, F4. 0, 4(2X, F8. 2))
       STOP
       END

       SUBROUTINE COR (X, N, Y, R, VX, VY, VD)
       DIMENSION X(I), Y(1)
       AN = N
       AP1 = 0.
       AP2 = 0.
       AP11= 0.
       AP12 = 0.
       D1 = 0.
       D2 = 0.
       DO 1 I = 1, N
       D = X (I) - Y(I)
       AP1 = AP1 + X(I)
       AP2 = AP2 + Y(I)
       AP11 = AP11 + X (I) * X(I)
       AP22 = AP22 + Y(I) * Y (I)
       AP12 = AP12 + X (I)* Y(I)
       D1 = D1 + D
       D2 = D2 + D* D
     1 VX = (AP11 - AP1 * AP1/AN)/AN
       VY = (AP22 - AP2 * AP2/AN) /AN
       VD = (D2 - D1* D1/AN)/AN
       R = (AP12 - AP1 * AP2/AN)/(AN * SORT (VX* VY))
       RETURN
       END
```